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NASA TECH BRIEF

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Strain-Age Cracking in Rene 41 Alloy

A reliable weldability test has been developed to investigate strain-age cracking in batches of the alloy Rene 41. This test has been used to determine the effects of material and process variables on the occurrence of this serious defect, and to demonstrate effective and practical means for reducing the extent of strain-age cracking.

Two welding studies, consisting of tensile, impact, and stress-rupture tests, were conducted. As far as possible, the same material was used in both studies, in order to allow direct comparison of results. Material and process variables considered were: solution-annealing temperature, time, and number of cycles; cooling rate; aging temperature; and alloy carbon content. Alloy characteristics of primary interest were ductility and toughness. Deviations from normal processing which resulted in either impaired or enhanced durability were noted.

Strain-age cracking resistance of each batch of Rene 41 may now be determined prior to its introduction into the manufacturing process. Evaluations may be performed with a controlled-heating-rate tensile test or a weld-circle patch test.

Low ductility in high-temperature air is the main factor contributing to strain-age cracking. Batches with less than two percent minimum elongation yield unsatisfactory results. Low carbon batches (less than 0.06%) show poor weldability, low ductility, and low toughness after aging. At 1400°F, the ductility of these batches averages two-thirds that of normal material.

When subjected to a rapid pre-aging cooling rate (up to 45°F/min), Rene 41 alloy shows improved toughness and ductility over a wide range of elevated temperatures.

Strain-age cracking resistance as well as the critical mechanical properties of toughness and ductility are improved by modification of the size, type, and distribution of the grain-boundary carbide particles and of the γ' precipitate. This is accomplished by using a pre-weld heat treatment and by performing post-weld annealing under an inert atmosphere.

One promising area for further investigation would involve the relationship between the type of heat-treating atmosphere and the amount of strain-age cracking.

Notes:

1. Information in a related field, investigation of strain-age cracking by electron microscopy, is presented in Rocketdyne report No. 66-20 (N69-71272).
2. For additional information write to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B69-10605

Patent status:

No patent action is contemplated by NASA.

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Category 03

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